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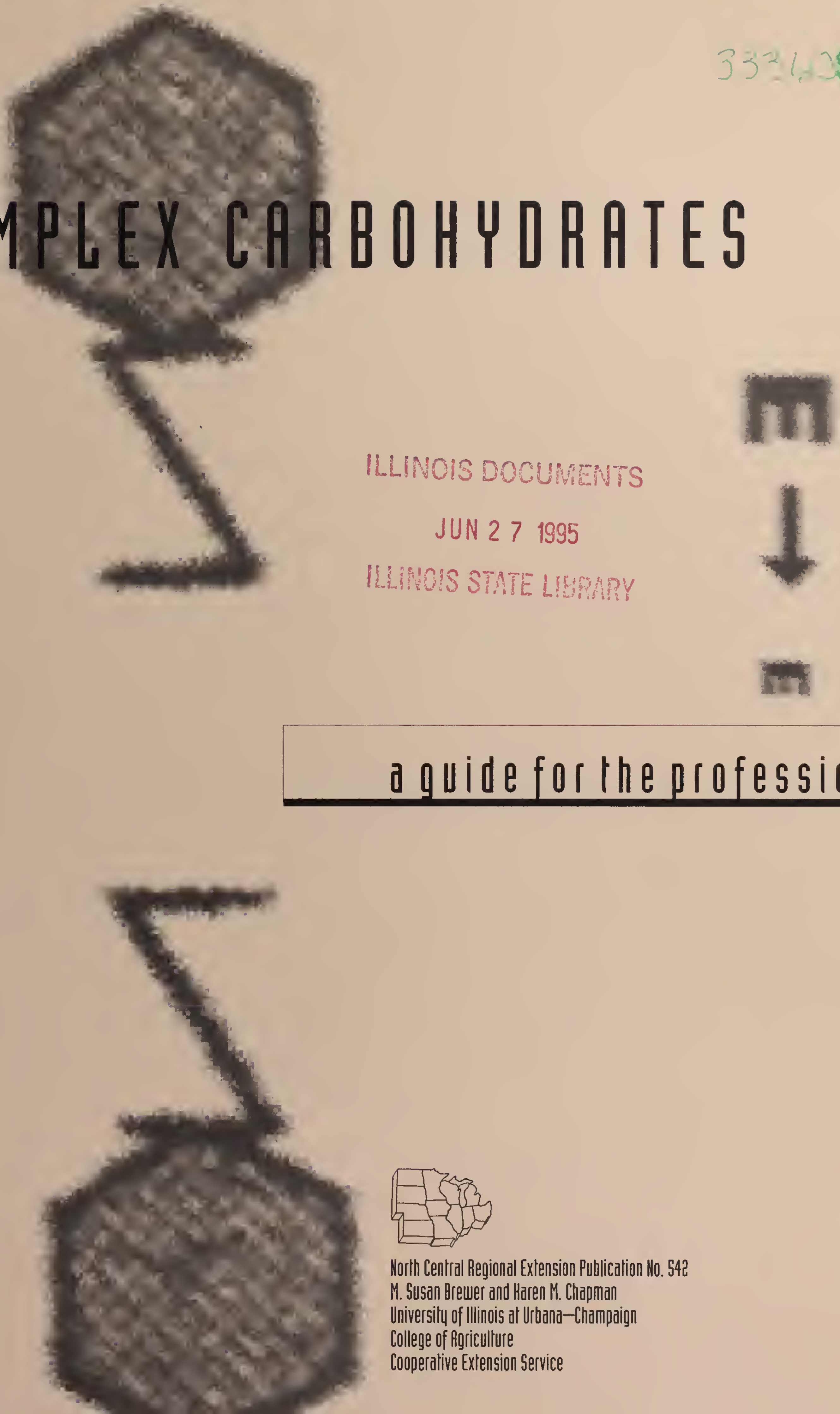
COMPLEX CARBOHYDRATES



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a guide for the professional

North Central Regional Extension Publication No. 542
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College of Agriculture
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Urbana, Illinois January 1995

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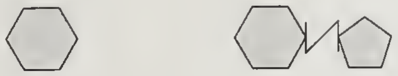
What Are Complex Carbohydrates and Fiber?

Carbohydrates are the most abundant class of organic molecules on earth. They are composed of three elements—carbon, hydrogen, and oxygen—arranged in specific ways to give each substance its unique characteristics. "Simple" carbohydrates, or sugars, are the building blocks of more complicated kinds of carbohydrates. Some of the simple sugars, such as fructose (fruit sugar) and glucose, are single carbohydrate units; others, such as lactose (milk sugar) and sucrose (table sugar), are composed of two carbohydrate units joined together by a chemical bond (Figure 1).



Glucose Sucrose

Figure 1. Glucose and sucrose molecules (stylized).

Complex carbohydrates, such as starch and cellulose, are composed of larger numbers of individual units ranging from 10 up to several thousand. Complex carbohydrates may be long strings of single units linked together like beads (Figure 2), or the chains may have branch points, making the molecule very bushy. Single carbohydrate units, or simple sugars, are readily absorbed by the body and need no digestion. Simple sugars are able to pass from the digestive system into the bloodstream very rapidly. Only simple sugars can be absorbed into the body.

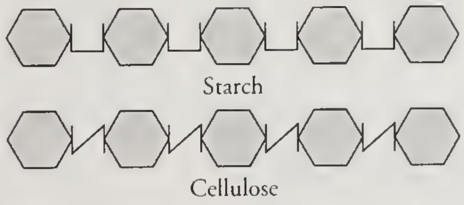
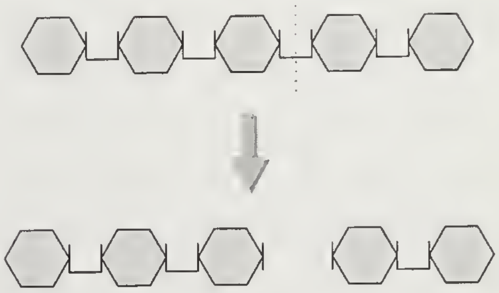


Figure 2. Cellulose and starch molecules (amylose, anylopectin).

Carbohydrates are joined together by chemical bonds like strings of beads and must be broken apart before they can be absorbed. Digestive enzymes break apart the bonds of carbohydrate units (Figure 3). These enzymes are very specific: they break apart only certain bonds (like the fructose-glucose bond of table sugar) and they can only break apart bonds that are spatially arranged in specific patterns.



Starch hydrolysis

Figure 3. Glucose hydrolysis from starch.

If the bonds between the carbohydrate units are the type that the digestive enzymes can break, the carbohydrate is "digestible" and will contribute calories to the diet. Digestive enzyme action results in simple sugars from complex carbohydrates. However, the single units are broken off from the larger molecule slowly so the sugars move into the bloodstream at a slower rate than if they were available all at one time.

If the bonds between carbohydrate units are a type that digestive enzymes **cannot** break, the carbohydrate is "indigestible." It passes through the digestive system without contributing calories to the diet. Most indigestible carbohydrate is termed "roughage" or "fiber." Fiber is important to the health of the digestive system because it attracts and holds water, swelling up like a sponge, which increases the bulkiness of the feces, making them easier to pass out of the body.

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Specific kinds of fiber have unique functions. Wheat fiber, which is primarily cellulose, reduces intestinal transit time and is fairly indigestible to intestinal microorganisms. The beta-glucans found in cooked legumes, on the other hand, are much more soluble, absorbing large amounts of water in the intestine to form a thick gel that increases intestinal transit time and provides fermentable substrates to intestinal microbes.

There is a group of complex carbohydrate substances that are indigestible by human enzymes and can be partially digested by the microbes that normally live in the intestines. These substances are generally dissolved in water, so they are referred to as "soluble fiber." Pectins, gums, and beta-glucans (oat bran) are in this category; they are composed of very "bushy" molecules (Figure 4) that swell up in water to form thick, jellylike substances. These substances contain sugars linked together by bonds that human enzymes cannot break. Microbes can digest these carbohydrates to produce acid substances in the colon that can be absorbed into the bloodstream. For this reason, soluble fibers contribute some calories to the diet.

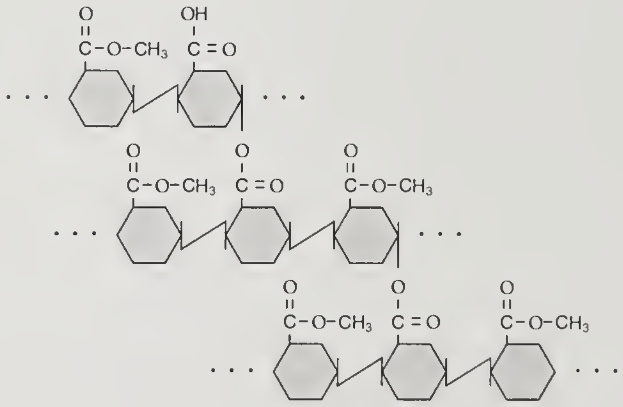

Figure 4. Pectin molecule.

Digestible and indigestible carbohydrates are found only in plant materials. Plants carry on photosynthesis to manufacture food-storage molecules (sugars and starches), structural materials (cellulose and pectins), and substances to repair tissue damage (gums).

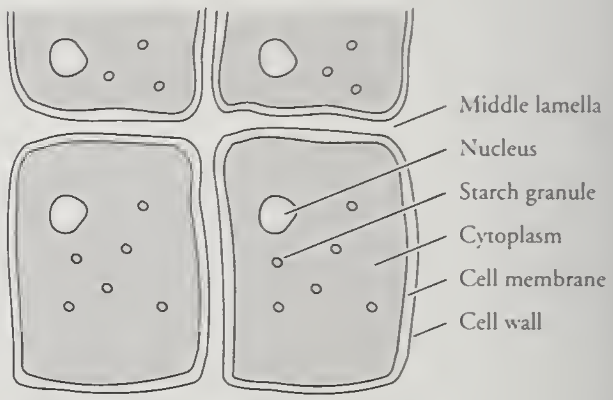

Figure 5. Plant cell parts.

In general, food-storage molecules (starch, simple sugars) are found *inside* the plant cell and are digestible by human enzymes (Figure 5). Sugars readily dissolve in water. Starch will not dissolve in cold water.

Structural materials found in the plant cell wall (cellulose) or between the cells (pectins) are indigestible by human enzymes. Cellulose gives plant cell walls their rigidity. Cellulose does not dissolve readily in water but softens during cooking of plant materials. Cellulose cannot be digested by intestinal microbes, so it attracts water and acts as a bulking agent. Pectins are the "glue" that hold plant cells together. Pectins from underripe fruits will not dissolve in water; pectins from mature fruits dissolve in water. Pectins absorb large amounts of water in the intestine to form a gel. This gel binds and traps fatty substances, increasing their excretion in the feces. In addition, the gel slows the rate at which digestive enzymes can break down digestible carbohydrates; this slows the movement of water and nutrients from the digestive tract into the bloodstream.

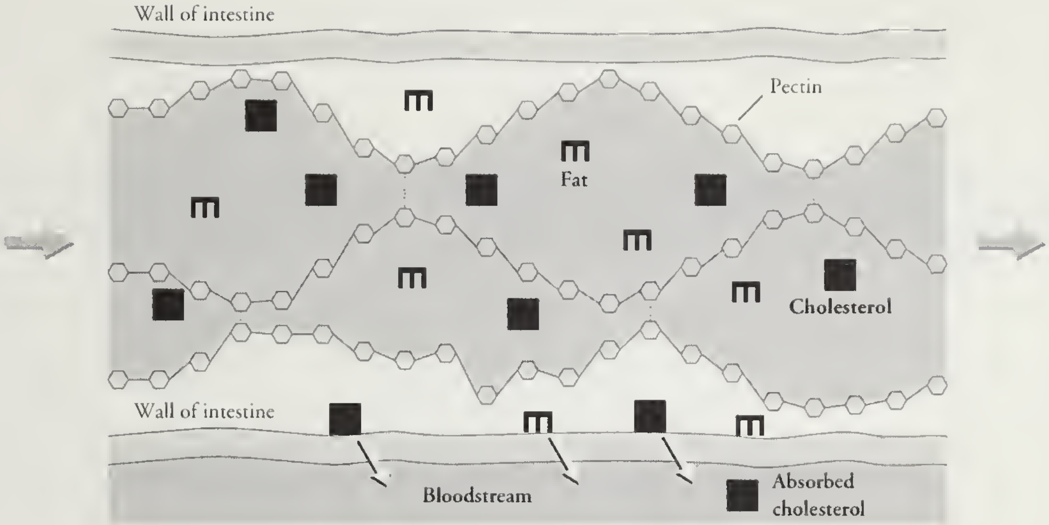

Figure 6. Pectin matrix binding cholesterol.

Gums (carrageenan, guar, tragacanth) are manufactured by plants as external protective substances wherever tissue damage occurs. Beta-glucans are gumlike substances made by some plants as an exterior protective coating; they occur in the bran layer (outer husk of seeds) to prevent the seeds from drying out. Gums dissolve readily in water, and many will thicken when heated. Gums are not digestible by human enzymes. Gums and pectins bind fatty substances such as cholesterol and bile acids in the human digestive tract (Figure 6). They can be digested by intestinal microorganisms.

Plants also manufacture indigestible substances that are not carbohydrates. The most common noncarbohydrate indigestible plant substance is lignin, which is a structural substance found in plant cell walls. It occurs as long strings that have a woody texture (celery, asparagus stalks). Lignin does not dissolve in water or soften when plant materials are cooked. Because it is indigestible, lignin functions similarly to cellulose and gums. Lignin does not absorb large amounts of water like pectins and gums, but it increases "bulk" in the intestine. Lignin speeds up the movement of waste products through the digestive tract. Lignin and cellulose increase the bulk of the feces; this makes it easier for the muscles of the large intestine to squeeze the wastes through its length. The intestine has to squeeze with less force, making it less likely that the intestine will develop a "pocket" at the site of a weak spot (Figure 7).

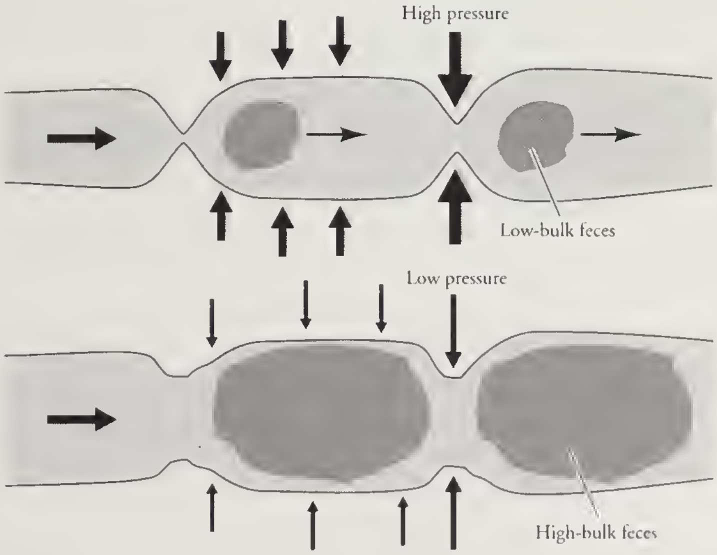

Figure 7. Effect of fecal bulk on pressure in the intestine.

Complex Carbohydrates and Fiber in the Diet

The average American consumes 10 to 15 grams of fiber a day. The Surgeon General's report, *Healthy People 2000*, recommends that adults increase their complex carbohydrate intake to five or more daily servings of vegetables and fruits, and to six or more daily servings of grain products. These dietary changes would increase fiber intake to between 20 and 35 grams of fiber a day. The recommendation for these dietary changes is based primarily on research linking higher fiber diets and reduced cancer incidence. Diets high in complex carbohydrates may play a positive role in cardiovascular disease and diabetes management. Substitution of lower fat, high complex-carbohydrate foods for higher fat foods also may promote weight reduction.

Cancer

National and international surveys suggest an association between diets rich in complex carbohydrates and lower incidence of specific cancers (colon, breast, lung, mouth, throat, stomach, bladder, cervix, and pancreas). High-fat diets have been associated with cancer of the breast, colon, pancreas, prostate, and uterus. There may be several ways in which these factors are related. A diet higher in complex carbohydrates may "dilute" the dietary fat, making it very difficult to determine whether the complex carbohydrates themselves play an active role in cancer protection or a passive, dilutional role. For instance, a person eating three or four servings of complex carbohydrate and a moderate amount of fat may have a fat intake of 37 percent of total calories. However, a person eating ten servings of complex carbohydrates and the same amount of fat would have a fat intake of about 28 percent of total calories because a larger percent of calories is coming from carbohydrates.

Various components of foods high in complex carbohydrates seem to play different roles in cancer prevention. Researchers suggested that dietary fiber was a protective factor in cancer over 15 years ago. Most research has focused on colon cancer and fiber. The lowest risk for colorectal cancer was found in populations with the highest fiber intake. Scientists thought that the increased fiber would increase stool bulk and decrease the length of time stool is in the intestine (transit time). This would decrease exposure to the carcinogen. However, the effects of fiber on transit time depend on many factors, including the nature of the fiber. Wheat fiber has been shown to both increase and decrease transit time, depending on the "pre-fiber" transit time. Although most types of fiber will increase stool bulk, this effect depends on the water-holding capacities of the fiber, which can be altered by food preparation and cooking.

Another possible explanation for the effects of complex carbohydrates in decreasing cancer risk involves fermentation by microorganisms in the large bowel. Some starch and all fiber remains undigested in the small intestine; some starch, soluble fibers, and insoluble fibers are available for microbial fermentation in the colon. Fermentation results in the production of short-chain fatty acids, the three most common being acetate, propionate, and butyrate. Butyrate is a short-chain fatty acid that serves as an energy source for the cells in the colon. Butyrate may stop the cancer cells from multiplying and thus may play a role in lowering cancer risk.

Foods high in complex carbohydrates also may be high in vitamin A and beta-carotenes. Studies have shown that as beta-carotene consumption increases, the incidence of lung cancer decreases. High complex-carbohydrate foods are often high in vitamin C as well. Studies suggest that vitamin C may have a protective effect against stomach cancer. Animal studies indicate that the mechanism may be through decreased activation of nitrosamines that can form when nitrite and protein-containing foods are cooked at high temperatures. Both vitamins C and A are antioxidants. Their antioxidant role may be important in cancer prevention.

The Brassica, or cabbage, family of vegetables (cruciferous vegetables) also may have anticarcinogenic action. These vegetables appear to have a special role in cancer prevention beyond their contribution of dietary fiber. A particular characteristic of these vegetables is that they contain sulfur.

Cancer Scenario

Ellen's father had died of lung cancer. Both grandfathers had died of prostate cancer. One of her grandmothers and her mother had had breast cancer. Ellen wanted to do all she could to prevent getting cancer herself. She didn't smoke, drank alcohol infrequently and moderately, and tried to exercise regularly. She had been thinking about trying to lower the fat and calories in her diet and had recently read that increasing complex carbohydrates might be helpful as well.

Let's look at Ellen's breakfast:
  1 1/2 cups corn flakes with 1/2 cup low-fat milk
  coffee
To increase complex carbohydrates, she may choose instead:
  1 whole-wheat English muffin
  1 bowl of strawberries
  coffee
Now let's look at Ellen's lunch:
  1 cup macaroni and cheese
  1/2 cup green beans
  1 slice bread with margarine
  iced tea
  2 chocolate chip cookies
To increase complex carbohydrates and decrease fat, she may choose instead:
  1 cup corkscrew pasta with Parmesan cheese
  1/2 cup green beans
  1 slice whole-wheat bread
  iced tea
  1/2 cantaloupe

Diabetes

Although high fiber intake in general has been shown to be associated with a lower diabetes incidence for populations, this relationship has not been shown to be causal. Indeed, intake of neither complex nor simple carbohydrates has been associated with the development of either insulin-dependent or noninsulin-dependent diabetes. Soluble fiber does, however, lower blood sugar levels in diabetics. The use of fiber supplements has not been endorsed due to a lack of evidence concerning the long-term safety of such treatment. Soluble fiber needs to be part of the food, or if added to foods, needs to be mixed well in order to have the blood glucose-lowering effect.

A variation in blood sugar response to different foods has been reported by many investigators. The term *glycemic index* has been used to evaluate the blood sugar response of certain foods compared to a standard. The glycemic response can graphically explain that all carbohydrates are not equal in terms of the rapidity of glucose appearing in the blood and peak concentration.

Fiber, fat, or the presence of other foods can alter glycemic responses. Fiber may delay gastric emptying time or slow absorption. Fat may also affect absorption rates, as may the presence of other foods. However, unless the food is eaten by itself or in very high proportion to the rest of the meal, glycemic indices for individual foods seems to have little impact in a standard diet.

The American Diabetes Association's nutritional principles concerning carbohydrates in the diet are summarized as follows:

1. Soluble fibers seem to cause improvement in blood sugar metabolism, but insoluble fibers may not.
2. Gradually increasing dietary fiber up to a maximum of 50 grams per day seems reasonable.
3. A variety of high-fiber foods should be selected as part of a diet in which carbohydrates contribute at least 50 percent of the calories.

There are concerns with the higher carbohydrate diets often used by diabetics:

1. There is the possibility of higher blood triglycerides, which may be temporary or permanent.
2. There is the possibility of low blood sugar (hypoglycemia) if insulin doses are not adjusted as soluble fiber intake is increased.
3. There is the possibility of mineral deficiencies developing with long-term use of high-fiber diets because fiber may bind to minerals in the intestine and decrease absorption.
4. There is the possibility of gastrointestinal disturbances occurring with the higher fiber intake because of increased stool bulk and changes in the speed at which stool passes through the intestine.

Diabetic Scenario

Mary was 61 years old and had known that she was diabetic for 20 years. In the last 15 years, Mary had started to put on weight. She was now 35 pounds heavier than she should be. Her doctor encouraged her to lose weight. Mary's blood sugar was too high at several of her recent doctor's appointments. Her dietitian told her to replace the simple sugars in her diet with complex carbohydrates, to follow her meal plan, and to stay within her prescribed calorie level.

Let's look at Mary's breakfast:
$^3/_4$ cup rice flakes with $^1/_2$ cup whole milk
6 oz. orange juice
2 slices white toast with margarine or jam
coffee

To increase complex carbohydrates and decrease simple sugars, she may choose instead:
$^3/_4$ cup rice flakes with $^1/_2$ cup low-fat milk
$^1/_2$ grapefruit
2 slices white toast with margarine or jam
coffee

To increase fiber as well as complex carbohydrates, Mary could choose:
1 cup oatmeal
6 oz. low-fat milk
$^1/_2$ grapefruit
1 slice whole-wheat toast with margarine
coffee

Now let's look at Mary's lunch:
lunch-meat sandwich with mayonnaise on white bread
1 oz. potato chips
3 chocolate chip cookies
12 oz. soda

To increase complex carbohydrates and decrease simple sugars, she may choose instead:
lunch-meat sandwich with sliced tomato on white bread
$^1/_2$ cup pasta salad
$^1/_2$ cup applesauce
iced tea

To increase fiber as well as complex carbohydrates, she may choose instead:
1 cup low-fat cottage cheese with 10 whole-wheat crackers
$^1/_2$ cup pasta salad
fresh apple
iced tea

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Food Sources of Selected Nutrients

Food	Grams	Quantity	Sugars	Complex carbohydrates	Total fiber	Soluble fiber	Insoluble fiber
FRUITS							
Apple (raw)	138	1 med.			***	*	**
Apple juice (canned, unsweetened)	168	6 fl. oz.	!		***	?	?
Applesauce (canned, sweetened)	128	1/2 cup			***	**	
Banana (raw)	114	1 med.			***	**	
Cantaloupe (raw)	160	1 cup		*	***	*	*
Grapefruit (raw)	123	1/2 med.			***	**	*
Grapefruit juice (canned, sweetened)	168	6 fl. oz.			?	?	?
Grapefruit juice (from concentrate)	168	6 fl. oz.	!		?	?	?
Grapes, American (raw)	92	1 cup			***	*	*
Orange (raw)	140	1 med.			***	*	*
Orange juice (canned, unsweetened)	168	6 fl. oz.	!		?	?	?
Nectarine (raw)	136	1 med.			***	**	
Kiwi (raw)	76	1 med.			***	**	
Mango (raw)	207	1 med.	!		***		**
Peach (raw)	87	1 med.			***		**
Pear (raw)	166	1 med.	!		***	*	*
Plum (raw)	66	1 med.			***	**	*
Prunes (dried)	34	4 prunes	!		***	?	?
Prune juice (canned)	172	6 fl. oz.	!			?	?
Pineapple (raw)	155	1 cup			**	?	?
Pineapple juice (canned)	168	6 fl. oz.	!		*	?	?
Raisins	100	2/3 cup	!		***	*	*
Strawberries (raw)	149	1 cup			***	**	*
Watermelon (raw)	160	1 cup			***	**	*
Fruit cocktail (canned, juicepack)	124	1/2 cup	!		?	?	?
BREAD/CEREAL							
Bread (white)	24	1 slice		***	***	**	*
Bread (whole-wheat)	24	1 slice		***	***	?	?
Muffin (homemade)	40	1 muffin					
Pancake	38	4" cake					

Food Sources of Selected Nutrients

Food	Grams	Quantity	Sugars	Complex carbohydrates	Total fiber	Soluble fiber	Insoluble fiber
FRUITS							
Apple (raw)	138	1 med.			***	*	**
Apple juice (canned, unsweetened)	168	6 fl. oz.	!		***	?	?
Applesauce (canned, sweetened)	128	1/2 cup			***	**	
Banana (raw)	114	1 med.			***	**	
Cantaloupe (raw)	160	1 cup		*	***	*	*
Grapefruit (raw)	123	1/2 med.			***	**	*
Grapefruit juice (canned, sweetened)	168	6 fl. oz.			?	?	?
Grapefruit juice (from concentrate)	168	6 fl. oz.	!		?	?	?
Grapes, American (raw)	92	1 cup			***	*	*
Orange (raw)	140	1 med.			***	*	*
Orange juice (canned, unsweetened)	168	6 fl. oz.	!		?	?	?
Nectarine (raw)	136	1 med.			***	**	
Kiwi (raw)	76	1 med.			***	**	
Mango (raw)	207	1 med.	!		***		**
Peach (raw)	87	1 med.			***		**
Pear (raw)	166	1 med.	!		***	*	*
Plum (raw)	66	1 med.			***	**	*
Prunes (dried)	34	4 prunes	!		***	?	?
Prune juice (canned)	172	6 fl. oz.	!			?	?
Pineapple (raw)	155	1 cup			**	?	?
Pineapple juice (canned)	168	6 fl. oz.	!		*	?	?
Raisins	100	2/3 cup	!		***	*	*
Strawberries (raw)	149	1 cup			***	**	*
Watermelon (raw)	160	1 cup			***	**	*
Fruit cocktail (canned, juicepack)	124	1/2 cup	!		?	?	?
BREAD/CEREAL							
Bread (white)	24	1 slice		***	***	**	*
Bread (whole-wheat)	24	1 slice		***	***	?	?
Muffin (homemade)	40	1 muffin					
Pancake	38	4" cake					
Waffle (from mix)	75	7" diam.					
Tortillas, corn	30	1 tortilla		***	***	**	*
Oatmeal (cooked)	175	2/3 cup		***	***	**	
Farina (cooked)	181	3/4 cup	*	***	***	*	*
Bran flakes	28	1/3 cup	*	**	***	*	**
Corn flakes	28	1-1/4 cup	*	***	***	*	*
Wheat flakes	28	2/3 cup	*	**	***	*	*
Frosted corn flakes	28	3/4 cup		*	***	*	*
Granola	28	1/4 cup		*	***	?	?
Puffed rice	14	1 cup	*	***		?	?
Rice, white (cooked)	160	1 cup	*	***	***	**	*
Rice, brown (cooked)	183	1 cup	*	***	***	?	?
Macaroni (cooked)	140	1 cup	?	***	***	*	*
Malt O'Meal	28	1 oz.	?	*	***	?	?
Oat bran	28	1 oz.	?	?	***	?	?
DESSERTS							
Apple pie (homemade)	111	1/8 pie	!				
Cheesecake	85	1 piece	?				
Cookie, chocolate chip	21	2 cookies	?				
Sherbet, orange	193	1 cup	!				
Ice cream (10% fat)	133	1 cup	!				
Cookie, oatmeal	13	1 cookie	?				
Cookie, sugar	16	2 cookies	?				
Chocolate cake (Pillsbury)		1/12 cake	?				
Brownie (Duncan Hines)	28	1 brownie	?				
LEGUMES/NUTS							
Kidney beans (canned)	256	1 cup	?	••	•••	••	•
Lima beans (canned)	241	1 cup		••	•••		
Navy beans (canned)	262	1 cup	?	••	•••	?	?
Soybeans (cooked)	172	1 cup		•	•••	?	?
Peanuts (dry roast)	28	1 oz.	•	••	•••		••
Peanut butter (creamy)	16	1 T.	•	•	•••		••
Sunflower seeds (dry roast)	28	1 oz.	•	••	•••	?	?
Garbanzo beans, canned	240	1 cup		••	•••	?	?
Lentils, cooked	198	1 cup	•	•••	•••	?	?

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Food Sources of Selected Nutrients, continued

Food	Grams	Quantity	Sugars	Complex carbohydrates	Total fiber	Soluble fiber	Insoluble fiber
VEGETABLES							
Broccoli (raw)	44	1/2 cup	*	*	***		**
Cabbage (raw)	35	1/2 cup	*		***		**
Carrots (raw)	75	1 med.			***		**
Cauliflower (raw)	50	1/2 cup	*	*	***	*	**
Corn (boiled)	82	1/2 cup	*	***	***		**
Cucumbers (raw)	52	1/2 cup	*		***	*	*
Green beans (boiled)	62	1/2 cup	*	**	***		**
Green pepper (raw)	50	1/2 cup	*	*	***	*	*
Mushrooms (raw)	35	1/2 cup	*	*	***		**
Potato (baked, skin on)	202	1 med.		***	***	**	*
Potato, sweet (baked)	114	1 med.		*	***	**	
Squash (summer)	65	1/2 cup	*	*	***	*	*
Tomatoes (raw)	123	1 med.			***		**
Tomato juice	182	6 fl. oz.		*	***	?	?
Peas (boiled)	80	1/2 cup		*	***	?	?
SNACK FOODS							
Popcorn, popped	6	1 cup					
Corn chips	28	1 oz.					
Potato chips	28	1 oz.					
Pretzels	28	1 oz.					
Saltines	12	4 crackers					
Ritz crackers	14	4 crackers					
Graham crackers (Nabisco)	14	2 crackers					
Rice cakes		1 cake					
Wheat Thins (Nabisco)	14	8 crackers					
Zwieback	7	1 piece					
Fruit Roll-up	15	1 roll					
DAIRY PRODUCTS							
Milk, whole	244	8 fl. oz.					
Milk, 2% fat	244	8 fl. oz.					
Milk, skim	244	8 fl. oz.					
Cheese, cheddar	28	1 oz.	*				
Yogurt (whole-milk)	227	8 fl. oz.					
Yogurt (low-fat)	227	8 fl. oz.					

Food Sources of Selected Nutrients, continued

Food	Grams	Quantity	Sugars	Complex carbohydrates	Total fiber	Soluble fiber	Insoluble fiber
VEGETABLES							
Broccoli (raw)	44	1/2 cup	*	*	***		**
Cabbage (raw)	35	1/2 cup	*		***		**
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Cauliflower (raw)	50	1/2 cup	*	*	***	*	**
Corn (boiled)	82	1/2 cup	*	***	***		**
Cucumbers (raw)	52	1/2 cup	*		***	*	*
Green beans (boiled)	62	1/2 cup	*	**	***		**
Green pepper (raw)	50	1/2 cup	*	*	***	*	*
Mushrooms (raw)	35	1/2 cup	*	*	***		**
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Tomatoes (raw)	123	1 med.			***		**
Tomato juice	182	6 fl. oz.		*	***	?	?
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SNACK FOODS							
Popcorn, popped	6	1 cup					
Corn chips	28	1 oz.					
Potato chips	28	1 oz.					
Pretzels	28	1 oz.					
Saltines	12	4 crackers					
Ritz crackers	14	4 crackers					
Graham crackers (Nabisco)	14	2 crackers					
Rice cakes		1 cake					
Wheat Thins (Nabisco)	14	8 crackers					
Zwieback	7	1 piece					
Fruit Roll-up	15	1 roll					
DAIRY PRODUCTS							
Milk, whole	244	8 fl. oz.					
Milk, 2% fat	244	8 fl. oz.					
Milk, skim	244	8 fl. oz.					
Cheese, cheddar	28	1 oz.	*				
Yogurt (whole-milk)	227	8 fl. oz.					
Yogurt (low-fat)	227	8 fl. oz.					
Cottage cheese (1% fat)	226	1 cup					
Cottage cheese (2% fat)	226	1 cup					
MEAT PRODUCTS							
Lean ground beef (baked)	100	3.5 oz.	**	0	0	0	0
Round steak (lean, broiled)	100	3.5 oz.	**	0	0	0	0
Sirloin (broiled)	100	3.5 oz.	**	0	0	0	0
Pork loin roast	100	3.5 oz.	**	0	0	0	0
Hot dog	57	1 frank	*	0	0	0	0
Ham, cured	28	1 slice.	**	0	0	0	0
Bologna, beef	23	1 slice	*	0	0	0	0
Chicken, light (roasted)	100	3.5 oz.	**	0	0	0	0
Tuna (canned/oil)	85	3 oz.	**	0	0	0	0
Whitefish, baked	100	3.5 oz.	**	0	0	0	0
Egg (hard-boiled)	50	1 large	**	0	0	0	0

Sugars
- ** Sugarfree .... <0.5 g/serving
- * Low sugar .... < 3 g/serving (10% of 2,000 cal/d ÷ 18 foods/d)
- ! Significant source .... ± 20 g/serving

Complex CHO and Low Fat (3 g fat or less/serving)
- * Moderate source .... 50% of total carbohydrates as complex carbohydrates
- ** Good source 70%
- *** Excellent source 90%

Fiber and Low Fat (3 g fat or less/serving)
- * Good source .... 3.2-2.39 g/1,000 cal
- ** High source .... 2.4 g/1,000 cal
- *** Excellent source .... 3.6 g/1,000 cal

Soluble Fiber, Low Fat (≤ 3 g fat/serving), and "excellent" source of total fiber (3.6 g fiber/1,000 cal)
- * Good source .... 10% of total fiber
- ** Excellent source .... 20% of total fiber

Insoluble Fiber and Low Fat and "Excellent" Source of Total Fiber
- * Good source .... 75% of total fiber
- ** Excellent source .... 90% of total

Foods in darkened rows **are not** low in fat.

In cooperation with the North Central Regional Educational Materials Project

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Cardiovascular Disease

Many different dietary changes have been investigated in attempts to lower the risk of cardiovascular disease. The risk factors most commonly considered are blood cholesterol and blood lipids. The blood lipids include low-density lipoproteins (LDL) and triglycerides. The most effective dietary change in lowering blood cholesterol and lipids is decreasing dietary fat intake.

Carbohydrates are good replacements for fat. Complex carbohydrates are recommended because simple carbohydrates can cause triglycerides to increase in some people.

Surveys have shown that vegetarians have lower blood cholesterol levels than nonvegetarians. This has been related to dietary fiber intake. Controlled studies suggest that high-fiber foods can lower blood cholesterol levels. However, not all dietary fiber has this effect. Those most effective seem to be the soluble fibers, such as pectin and oat gum. Legumes, such as pinto and navy beans, are generally good sources of fiber and elicit favorable reductions in LDL. Soybean fiber and soybean protein both have been shown to have hypocholesterolemic effects. Corn bran and rice bran have also been investigated with variable results.

Cardiovascular Disease Scenario

Ted was 51 years old and had always felt he was in good health. However, last winter, he couldn't seem to recover from a cold, which had progressed to bronchitis. During an exam, his blood was checked for lipid levels. Ted was told his cholesterol and lipids were too high. He was educated on a low-fat, low-cholesterol diet. Unfortunately, Ted just eliminated the high-fat, high-cholesterol foods and did not replace them with other foods. He was hungry all the time and felt the diet was impossible.

Let's look at Ted's breakfast:
- 2 slices dry toast
- coffee

To increase complex carbohydrates and increase the size of breakfast, he could choose instead:
- 2 slices dry toast
- $^3/_4$ cup wheat flakes with $^1/_2$ cup skim milk
- 1 banana
- coffee

To increase fiber as well as complex carbohydrates, Ted could choose:
- 2 slices whole-wheat toast
- $^3/_4$ cup bran flakes with $^1/_2$ cup skim milk
- 1 banana
- coffee

Now let's look at Ted's lunch:
- 98% fat-free lunch-meat sandwich
- 10 vanilla wafers
- 12 oz. diet soda

To increase complex carbohydrates and increase the meal size, Ted could choose instead:
- 98% fat-free lunch-meat sandwich
- 1 oz. pretzels
- carrot sticks
- 10 vanilla wafers
- 12 oz. diet soda

To increase fiber as well as complex carbohydrates, he could choose instead:
- 98% fat-free lunch-meat sandwich on whole-wheat bun with lettuce
- 1 oz. pretzels
- carrots and celery sticks
- 6 graham crackers
- fresh peach
- 12 oz. diet soda

Boosting Your Dietary Fiber Intake

1. Eat a variety of foods.
2. Eat three to five servings ($^1/_2$ cup) of vegetables, two to four servings of fruit ($^1/_2$ cup, 6 fluid ounces, or 1 medium), and six to eleven servings of grains, cereals, pasta, and rice (1 slice bread or $^1/_2$ cup rice, pasta, cooked cereal).
3. Eat more legumes (kidney beans, lima beans, split peas). Most legumes are low in fat and high in protein.
4. Add vegetables, legumes, and grains to soups and casseroles. Pureed, they can be used to thicken hot soups.
5. Add fruit to low-fat yogurt or cottage cheese as a salad. Puree fruit with yogurt or low-fat milk and freeze to make a dessert or snack.
6. Add whole, chopped, or pureed fruits or vegetables to muffins, breads, and other baked goods.
7. Try unfamiliar fruits (mango, kiwi, starfruit), vegetables (leeks, jicama, arugula), grains (buckwheat, barley, couscous), and legumes (black-eyed peas, lentils, garbanzo beans), to add variety, complex carbohydrates, and dietary fiber to your diet.

Remember:

1. Add high-fiber foods to your diet slowly to allow your system time to adapt to the increased bulk and water and increased rate of stool passage through the system. Rapid introduction of large amounts of high-fiber foods can cause gastrointestinal distress.
2. Chew fiber-containing foods well.
3. Drink plenty of liquids.

Reading the Label

A variety of information about a food product occurs on the label. Food labels are changing; the purpose of the Nutrition Labeling and Education Act (1990) was to provide the consumer with more useable information. *What is on the label that will help you choose complex carbohydrates?*

- List of Ingredients

  Ingredients are listed in *descending order by weight*. If several ingredients, like spices, make up less than 2 percent of the product, they may be grouped together and listed as "spices."

  a. "Sugars" can be used as a collective term and placed in the ingredient list with the components listed in parentheses in descending order: sugars (sucrose, honey, molasses). "Sugars" includes mono- and di-saccharides.

  b. Specific ingredients that may have adverse effects for some people must be listed specifically. These include all FDA-certified food colors, sulfites, monosodium glutamate (MSG), and hydrolyzed protein. In addition, caseinate must be identified as derived from milk protein.
- Nutrition Labeling

  a. Serving Size

  This is the portion commonly consumed by the average person over 4 years of age. Serving size is listed in common units (pound, ounce, cups, pieces, etc.) and in metric measurements (grams).

  b. Nutrient Listing

  Nutrients that must be listed in terms of *amount per serving* include total calories, calories from fat, total fat, saturated fat, cholesterol, sodium, *total carbohydrates*, *dietary fiber*, *sugars*, protein, vitamin A, vitamin C, calcium, and iron.

Nutrition information also can be listed as percentages of dietary reference values such as the Reference Daily Intake (previously the U.S. Recommended Dietary Allowance) or the Daily Reference Values (DRV). The DRV is used for eight food components that are important to maintaining good health: fat, saturated fat, unsaturated fat, cholesterol, *carbohydrate*, *fiber*, sodium, and potassium. The reference caloric intake for determining DRVs is 2,000 calories; persons with higher or lower caloric need should adjust their other nutrient intakes accordingly.

Presence or absence of a particular food component is considered to be a "health claim." Some types of "health claims" are permitted to be made on food labels, including the health relationships between (1) sodium and hypertension, (2) saturated fat and cholesterol and cardiovascular disease (CVD), (3) fat and cancer, (4) calcium and osteoporosis, (5) *fiber-containing grain products, fruits and vegetables, and cancer*, (6) *fiber-containing grain products, fruits and vegetables, and risk of* CVD, and (7) *fruits and vegetables and cancer*.

Under the new food labeling regulations, the following proposed terms may be used on labels to describe specific product characteristics.

Free: means a product contains no or a "physiologically inconsequential" amount of one or more of the following: fat, saturated fat, cholesterol, sodium, *sugars*, and calories. Synonyms for "free" include "without," "no," and "zero."

Calorie-free: fewer than 5 calories per serving.
Sugar-free: less than 0.5 g per serving.
Fat-free: less than 0.5 g per serving.

High: can be used if the food contains 20 percent or more of the DRV for a particular nutrient in a serving.

Good Source: means that one serving of a food contains 10 to 19 percent of the DRV for a particular nutrient.

Light:

1. A nutritionally altered product that contains one-third fewer calories or half the fat of the reference food. If the food derives 50 percent or more of its calories from fat, the reduction must be 50 percent of the fat.

Daily Reference Values for 2,000 and 2,500 Calories

Nutrient	DRV, 2,000 calories	DRV, 2,500 calories
Total fat (≤ 30% of calories)	≤ 65 g	≤ 80 g
Saturated fat (≤ 10% of calories)	≤ 20 g	≤ 25 g
Cholesterol	≤ 300 mg	≤ 300 mg
Carbohydrate (≥ 60% of calories)	≥ 300 g	≥ 375 g
Fiber	25 g	25 g
Sodium	< 2,400 mg	< 2,400 mg

2. The sodium content of a low-calorie, low-fat food has been reduced by 50 percent. In addition, "light in sodium" may be used on food in which the sodium content has been reduced by at least 50 percent.
3. The term "light" can still be used to describe texture and color as long as the label explains the intent (light brown sugar).

More: means that a serving of food, whether altered or not, contains a nutrient that is at least 10 percent of the DRV more than the reference food. The 10 percent of DRV would also apply to "fortified," "enriched," and "added" claims, but in those cases, the food must be altered.

Implied: These types of claims are prohibited when they wrongfully imply that a food contains or does not contain a meaningful level of a nutrient. For example, a product claiming to be made with an ingredient known to be a source of fiber ("made with oat bran") is not allowed unless the product contains enough of that ingredient (oat bran) to meet the definition for "good source" of fiber.

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